LITERATURE CITED

1. N. V. Karlov and A. M. Prokhorov, Usp. Fiz. Nauk, 118, No. 4, 583 (1976).
2. K. S. Gochelashvili, N. V. Karlov, A. N. Orlov, et al., Pis'ma Zh. Eksp. Teor. Fiz., 21, No. 11, 640 (1975).
3. K. S. Gochelashvili, N. V. Karlov, A. I. Ovchenkov, et al., Zh. Eksp. Teor. Fiz., 70, No. 2, 531 (1976).
4. K. S. Gochelashvili, N. V. Karlov, N. A. Karpov, et al., Pis'ma Zh. Tekh. Fiz., 2, 721-726 (1976).
5. V. B. Kazanskii and N. D. Chuvylkin, Dokl. Akad. Nauk SSSR, 223, 910 (1975).
6. A. B. Kazanskii, Theory of Filtration Diffusion and Its Application to Problems of Hydrology and Hydrogeology [in Russian], Nauka (1973).
7. S. Ribinkar, Byull. Inst. Yad. Issled. (Belgrad, Yugoslavia), 8, 147 (1958).

LASER ACTION ON THERMAL DIFFUSION OF GASES

N. V. Karlov, Yu. N. Petrov,
and I. V. Fedorov

1. Excitation of molecules or atoms by laser radiation leads to change in their interaction with one another, as well as with molecules or atoms of other substances or other phase states. The difference between the interaction of excited and unexcited molecules is used in a number of methods of laser separation of isotopes and substances [1]. Thus, changes in evaporation and condensation of vibrationally excited molecules make it possible to realize selectively proceeding processes in essentially heterophase systems [2]. Of no less interest is the influence of vibrational excitation of molecules on thermal diffusion in a multicomponent gas mixture or, in other words, resonant laser action on a thermal diffusion of gases.

2. Under the action of laser radiation, the resonantly absorbing molecules acquire an induced dipole moment. This leads to a change in the character of these molecules, both with one another and with excited molecules, owing to the decrease in the order of the multiplicity. A particularly strong change should take place in the interaction for molecules that have no dipole moment in the unexcited state. It appears that it is precisely this change in the character of the interaction which determines the anomalies of the nonequilibrium excitation of the vibrational spectrum of boron trichloride molecules by CO_2 laser radiation under collision conditions [3]. Consequently, vibrational excitation of the molecules should lead to a change in the form and magnitude of the interaction potential of the colliding molecules.

An insignificant change in the form of the interaction of the molecules can lead to a change in the character of the diffusion and thermal diffusion of the gases. This is confirmed by the observed appearance of the singularities in the transfer of the vibrational-excitational energy when molecules collide at high temperatures [4].

The phenomenologically established thermal diffusion is described by an equation [5] that relates the difference between the average velocities of the two types of molecules, u_1 and u_2, with the gradients $\partial n/\partial \mathbf{r}$ and $\partial T/\partial \mathbf{r}$ of the density and temperature, respectively:

$$\mathbf{u}_1 - \mathbf{u}_2 = -\frac{D_{12}}{n_1 n_2}\left(\frac{\partial n_1}{\partial \mathbf{r}} + \alpha n_1 n_2 \frac{1}{T}\frac{\partial T}{\partial \mathbf{r}}\right), \qquad (1)$$

where n_1 and n_2 are the relative volume densities; the subscript 1 pertains to the heavier molecule; D_{12} is the concentration diffusion coefficient; α is the thermal-diffusion constant.

There is a known equation for the constant α, obtained [5] in first-order approximation in terms of a function of the collision integrals C, S, and Q:

$$\alpha = 5(C-1)\frac{S_1 n_1 - S_2 n_2}{Q_1 n_1^2 + Q_2 n_2^2 + Q_{12} n_1 n_2}. \qquad (2)$$

Translated from Trudy Ordena Lenina Fizicheskogo Instituta im. P. N. Lebedeva, Vol. 114, pp. 174-183, 1979.

0270-2010/81/0203-0231$07.50

The collision integrals depend on the form of the interaction, temperature, and the mass ratio of the colliding molecules.

The thermal diffusion constant α, generally speaking, depends on the temperature. Independence of α of temperature can be obtained in a model in which the molecules are regarded as hard spheres. The temperature dependence repeatedly observed in experiment for polyatomic molecules [5] is quite complicated. When the temperature drops from high values to $\sim 10T_c$ (T_c is the critical temperature of the gas) α increases slightly, and then decreases rapidly and takes on negative values at a temperature near $1.5T_c$, reaching the maximum negative value at $\sim 0.5T_c$. One usually introduces the relative thermal-diffusion constant $R = \alpha/\alpha_0$, where α_0 is calculated on the basis of the hard-sphere model. When the temperature is increased, in the region $T > 10T_c$, the value of R tends to 0.6 for noble gases and to 0.3-0.4 for polyatomic molecules.

From Eq. (1) at a specified value of α, it is easy to obtain a simple connection between the coefficient of thermal-diffusion separation η and the temperature T_{hot} and T_{cold} in the hot and cold regions

$$\eta = (T_{hot}/T_{cold})^{\alpha}. \qquad (3)$$

Here, by definition, $\eta = \frac{n_{1\,hot}}{n_{2\,hot}} \Big/ \frac{n_{1\,cold}}{n_{2\,cold}}$.

An analysis of the collision integrals that enter in (2) shows that the difference between the masses of the mixture molecules does not influence strongly the value of α. In fact, large values of α are obtained only for binary mixtures with large mass ratios: e.g., at m_1/m_2 = 2-20 the values of α lie in the range 0.15-0.4 [6]. In the case of heavy molecules with small difference (isotope mixture), α is small. At the same time, an analysis of (2) shows that α depends strongly on the form of the interaction potential of the colliding molecules. Therefore, vibrational excitation of the molecules can strongly increase the value α, thus offering evidence that laser thermal diffusion is promising.

Thus, in laser thermal diffusion (LTD) the resonant laser radiation under collision conditions, by radiatively exciting molecules of one isotopic composition, which in turn excite, via V—V quasiresonant exchange, the molecules of the other isotopic composition, increases the differences between the parameters of the collision processes in which these molecules participate. It is this which should lead to an increase of the thermal-diffusion constant α. Obviously, at constant selectivity of the laser action on the molecules of one isotopic composition, the influence of the vibrational excitation on the diffusion of these molecules increases strongly. Strictly speaking, in this case the term "thermal diffusion" is no longer applicable. In addition, in the case of heavy molecules with small isotopic shift and fast V—V exchange, it is necessary to consider not binary but ternary mixtures and analyze the difference in the diffusion of the vibrationally excited and unexcited molecules in the buffer gas. The case of like molecules, just as the case of essentially nonstationary interactions, calls for a special treatment.

It should be noted that as a result of the molecule collisions the energy of the laser radiation goes over in the V—T relaxation process into thermal energy. Owing to the strong heating of the absorbing gas, the LTD is accompanied by ordinary thermal diffusion. This

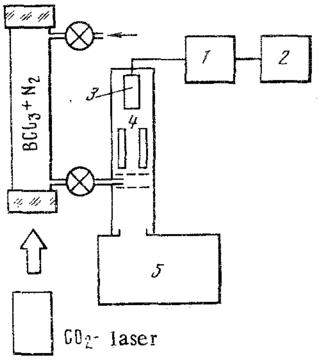

Fig. 1. Experimental setup for mass-spectral investigation of LTD. 1) Amplifier; 2) automatic recorder; 3) secondary-electron amplifier; 4) quadrupole; 5) high-vacuum pump.

thermal diffusion was obtained in laser heating of the molecular mixture Br_2 + Xe by argon-laser radiation [7].

We have experimentally investigated diffusion processes in the molecular systems $^{10}BCl_3$ + $^{11}BCl_3$, as well as in BCl_3 mixed with other gases, under the influence of CO_2-laser radiation at resonance with the ν_3 vibration of $^{11}BCl_3$ (956 cm^{-1}). The isotopic shift of the ν_3 vibration for the molecules $^{10}BCl_3$ and $^{11}BCl_3$ amounts to 40 cm^{-1}.

3. Mass spectrometric investigations of LTD were carried out with the KM-2 quadrupole mass spectrometer. In the experiments we used an LG-25 CO_2 laser with radiation power up to 30 W. The laser radiation, collimated into a parallel beam of ∿1 cm, passed through a vertically placed cell with the investigated gas mixture (see Fig. 1). The cell, made of stainless steel, had NaCl windows. The cell diameter was 3 cm and the length 40 cm. The cell walls were cooled with running water at room temperature. The gas for the analysis was drawn from the peripheral part of the lower end of the cell (on the side where the laser radiation entered). To shorten the analysis time, the cell was mounted directly on the entrance leak valve of the mass spectrometer, through which the gas was fed into the ionization chamber. The experiments were performed at analyzed-gas fluxes $\sim 3 \cdot 10^{14}$ particles/sec into the mass spectrometer, and the pressure in the mass-spectrometer chamber did not exceed 10^{-8} torr in this case. A high sensitivity of the apparatus was ensured by heating the chamber before each run of experiments and by evacuation to 10^{-8} torr. The mass-spectrometer chamber was evacuated with a NORD-100 electric-discharge pump. At such samplings of the gas for the analysis, the relative change of pressure in the working cell, in continuous operation for one hour, did not exceed 5%. Therefore, the influence of the gas sampling on the development of the diffusion processes in the cell can be neglected.

We investigated the LTD of the gases $^{10}BCl_3$ and $^{11}BCl_3$ with natural ratio of isotopes and of a mixture of BCl_3 and N_2 with varying concentrations in the pressure range from 1 to 500 torr.

The mass-spectrum analysis of BCl_3 and N_2 was based on the ^{10}B, ^{11}B, ^{14}N elemental peaks. The absence of impurity peaks on the m/e = 10, 11, 14 markers, their proximity, and the relative commensurability of the amplitudes, have all made it possible to analyze the gas concentrations with accuracy better than 1%.

A typical mass spectrogram of the mixture $BCl_3 + N_2$ = 38 torr + 14 torr, showing the change of the concentrations of these gases in the cold region of the cell upon application of the laser radiation, is shown in Fig. 2.

The separation coefficient η was defined by us as the ratio $nBCl_3/nN_2$ in the cold region of the cell, from which the gas was drawn for analysis, with the laser radiation turned off, to the standard n^0BCl_3/n^0N_2 in the absence of radiation. This definition of η yields lower values than the definition of η as the ratio of the concentrations in the cold and hot regions.

The following results were obtained. For the mixture $BCl_3:N_2$ = 1:1 at a radiation power 28 W $\eta = 1.20$ (total pressure P = 1.5 torr), $\eta = 1.25$ (P = 15 torr), $\eta = 1.60$ (P = 45 torr), $\eta = 0.80$ (P = 260 torr). When the laser is turned on, an abrupt change takes place in the ratio of the concentrations in the cold region of the cell (at the entrance to the mass spectrometer) within a time on the order of 1 min. This is followed by a slight smooth change in the concentration ratio, and a stationary regime is reached after 10-30 min (this time characterizes the time constant of the channel joining the cell with the mass spectrometer).

The dependence of the separation coefficient on the BCl_3 concentration in the mixture with N_2 at a 38-torr partial pressure of the BCl_3 and 28-W irradiation power is shown in Fig. 3. The plot recalls the temperature dependence of the thermal-diffusion constant.

The heating of the gas mixture in the region of the laser beam is due to absorption of the radiation by the BCl_3 molecules (absorption coefficient $\beta = 0.066$ $cm^{-1} \cdot torr^{-1}$). The temperature T_{hot} and the dimension of the hot region can be estimated. The temperature dependence of the thermal conductivity coefficient of the mixture was approximated by a linear function. Account was taken of the NaCl window in the calculation of the thermal conductivity. At a constant heat flow, at $nBCl_3$ = 0.6-0.7, the temperature of the gas in the absorption region does not exceed 1500°K in the described experiment and decreases almost linearly with decreasing n of BCl_3. Since the laser radiation is practically completely absorbed in the lower

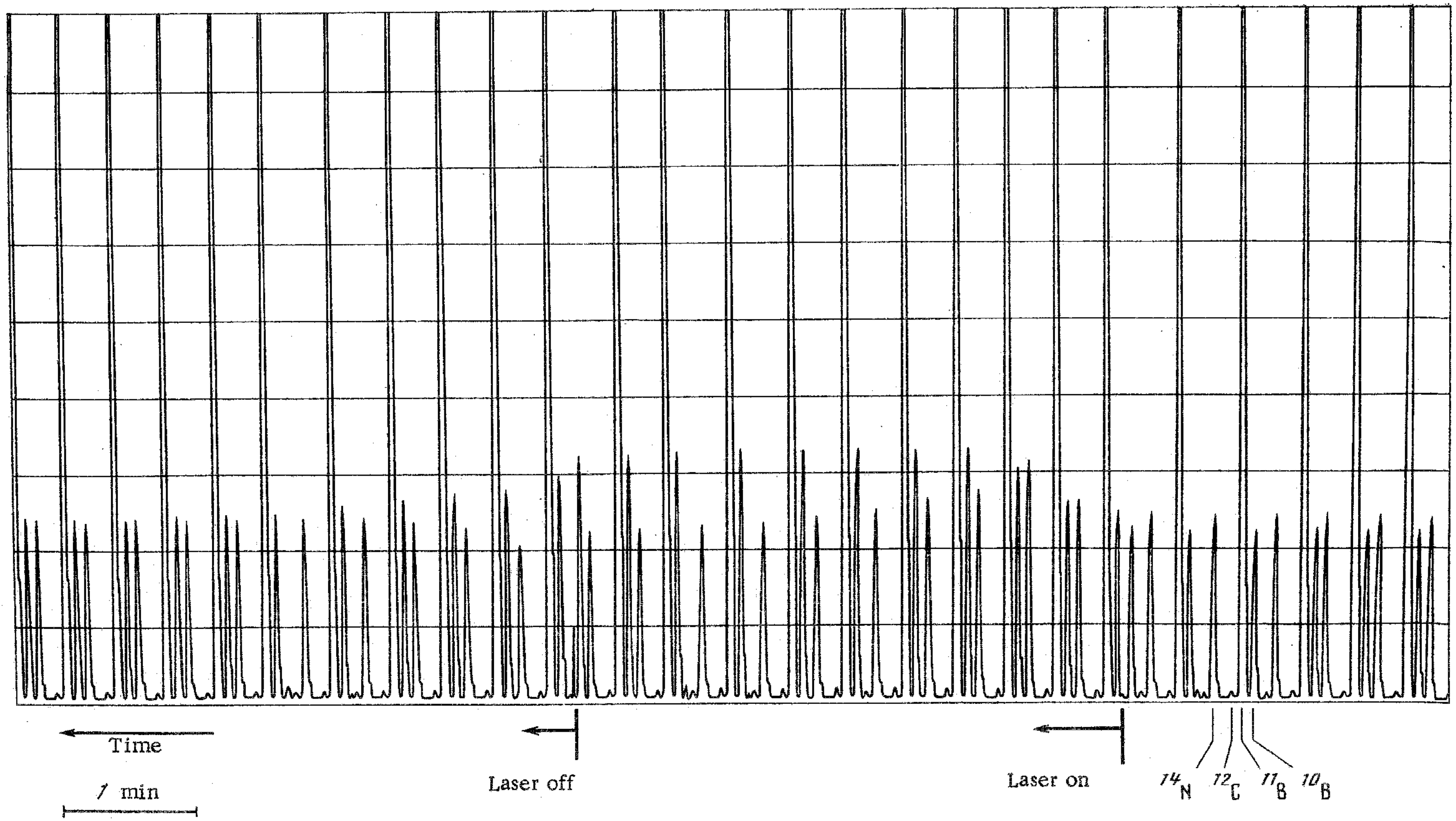

Fig. 2. Mass spectrogram of the gas mixture $BCl_3 + N_2 = (38 + 14)$ torr acted upon by CO_2 laser radiation.

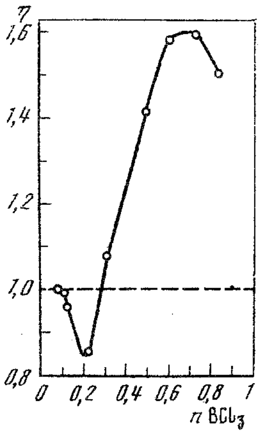

Fig. 3

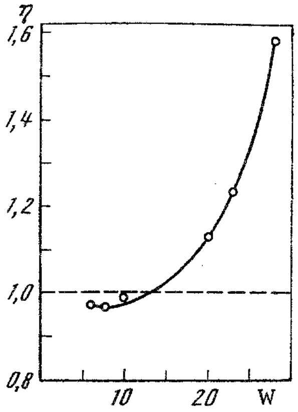

Fig. 4

Fig. 3. Dependence of the separation coefficient $\eta = \left(\frac{n\mathrm{BCl_3}}{n\mathrm{N_2}}\right)_{\mathrm{cold}} \Big/ \left(\frac{n\mathrm{BCl_3}}{n\mathrm{N_2}}\right)_0$ for the mixture $BCl_3 + N_2$ on the BCl_3 concentration. The partial pressure of the BCl_3 is 38 torr, the irradiation power is 28 W.

Fig. 4. Dependence of the separation coefficient $\eta = \left(\frac{n\mathrm{BCl_3}}{nN_2}\right)_{\mathrm{cold}} \Big/ \left(\frac{n\mathrm{BCl_3}}{n\mathrm{N_2}}\right)_0$ for the mixture $BCl_3 + N_2$ = (38 + 22) torr on the irradiation power.

layer of the gas in the cell (the intensity is attenuated by a factor of 10 in a 9-mm layer), the gas heating in the remaining axial region of the cell is negligible. The slight increase of the total pressure in the cell following the turning on of the laser is also evidence of the small temperature drop of the gas, averaged over the height of the cell, between the axial and peripheral region ($\Delta T < 100$°K). Therefore, diffusion separation of the gas-mixture components takes place only in the lower region of the cell, and the resultant convection gas streams lead only to a mixing of the mixture and to a weakening of thermal diffusion.

The measured values of the separation coefficients describe the process of LTD of the molecules between the hot region of radiation absorption with temperature T_{hot}, on the one hand, and the cold gas region ($T_{\mathrm{cold}} \cong 300$°K) located directly at the entrance to the mass spectrometer.

Thus, the curve of Fig. 3 reflects the temperature dependence of the LTD process with a characteristic transition of η into the region <1 ($\alpha < 0$) at $T \cong 1.5$(T_c is 570°K for the mixture $BCl_3 + N_2$). Using the expression (3) and the experimental value, we can obtain α. For the region of saturation of η at high temperatures (the three upper points on the curve) we have $\alpha = 0.25$–0.29, $R = 0.66$–0.73.

Similar results are obtained by reducing the experimental dependence of the separation coefficient on the laser-radiation power (Fig. 4) for the mixture $BCl_3 + N_2$ at a pressure 60 torr ($nBCl_3 = 0.63$).

The large values of R are evidence of the difference between the LTD process and thermal diffusion even in the case of a nonisotopic mixture. In an isotopic mixture this difference is even more noticeable.

In experiments on LTD of the isotope mixture $^{10}BCl_3 + {}^{11}BCl_3$, and also as a result of an analysis of the ratio of the concentration of $^{10}BCl_3$ and $^{11}BCl_3$ in a $BCl_3 + N_2$ mixture, separation coefficient values up to 1.03 $\left(\eta = \frac{n\,{}^{11}\mathrm{BCl_3}}{n\,{}^{10}\mathrm{BCl_3}} \Big/ \frac{n^0\,{}^{11}\mathrm{BCl_3}}{n^0\,{}^{10}\mathrm{BCl_3}}\right)$ were obtained at BCl_3 pressures of ≈30 torr. The separation coefficient decreases rapidly with increasing irradiation power and with the decreasing partial pressure of the BCl_3. A 3% enrichment of the mixture with $^{11}BCl_3$ molecules in the cold region corresponds to $\alpha = 0.018$ and $R = 4.77$. A similar enrichment (2–3%) of such a mixture can be expected in ordinary thermodiffusion only at $T_{\mathrm{hot}}/T_{\mathrm{cold}} = 4 \cdot 10^5$–$2 \cdot 10^9$.

TABLE 1

№	Partial pressure, torr		Separation coeff. η	Laser-radiation power, W	Beam diam., mm	Analyzed region
	BCl_3	He				
1	3,7	0	0,970±0,005	50	25	Hot
	18,7	0	0,981±0,005			
	37,5	0	0,990±0,005			
	75,0	0	0,994±0,004			
2	3,7	37,5	0,966±0,006	50	6	Hot
	7,5	75,0	0,981±0,005			
3	3,7	37,5	0,970±0,008	15	25	Hot
			0,964±0,009	17,5		
			0,950±0,007	25		
			0,934±0,006	50		
4	37,5	0	0,990±0,005	50	6	Hot
	37,5	375	1,004			Cold
5	7,5	150	1,016±0,004	20	6	Cold
6	37,5	375	1,021±0,007	20	Focus	Cold
7	37,5	139	1,021±0,003	50	6	Cold

We note that such a strong LTD process is naturally extremely sensitive to changes in the parameters of the irradiated molecular system. A particularly strong influence on the LTD is exerted by the gas temperature and by the irradiation intensity, variation of which can cause the thermal diffusion constant α to reverse sign. The strong dependence of the process on the temperature and on the temperature gradient complicates the theoretical analysis of the LTD, since α cannot be regarded as constant over the entire temperature-drop region. This remark pertains in particular to polyatomic gases, which have as a rule high T_c. In a thermal-diffusion system consisting of such gases there exist near the cold wall extended sections with negative α. However, inasmuch as in laser heating of a resonant mixture there is a large "temperature reserve," it may be advantageous to raise the temperature of the cold wall in order to increase the integral separation effect.

4. If the isotope mixture of the gases is diluted with an inert gas, one can expect selective excitation of the resonant component by the laser radiation and an increase of the diffusion separation. We have carried out a mass-spectrometer investigation of LTD in a $^{10}BCl_3 + {}^{11}BCl_3 + He$ mixture irradiated with a laser at a power up to 50 W. The stainless-steel cell of 3-cm diameter and 12-cm length was horizontally placed. The gas was drawn for the analysis through a thin steel tube of 0.5-mm diameter from either the hot or the cold region of the cell.

The following results were obtained (see Table 1). In the hot region of the cell, the mixture is enriched with $^{10}BCl_3$ molecules compared with the standard, while in the cold region it is enriched with $^{11}BCl_3$. In the isotope mixture $^{10}BCl_3 + {}^{11}BCl_3$ without helium, the enrichment decreases with increasing pressure (No. 1), and the same occurs also in the mixture with the helium (No. 2). The run No. 3 shows an increase of the enrichment with increasing irradiation power. At high irradiation intensities, dissociation of the BCl_3 molecules takes place in the beam region, accompanied by visible luminescence, and addition of helium to the BCl_3 eliminates the dissociation. Addition of helium lowers the gas temperature and shortens the hot zone. If the tube used to draw the gas is placed at the edge of the hot zone in BCl_3, then upon addition of the helium the tube may turn out to be in the cold zone (No. 4). Despite of the lowering of the temperature, the addition of helium strengthens the LTD process and makes it possible to obtain high separation coefficients (No. 3). In the mixture with the helium there were obtained noticeable separation coefficients even at relatively high pressures of the BCl_3 (No. 6, 7). We have also carried out IR-spectral investigations of LTD in the mixtures $^{10}BCl_3 + {}^{11}BCl_3 + He$. The laser radiation was directed into a wide glass cell located in the cell section of the IKS-22 spectrometer, parallel to the globar beam. The cell diameter was 10 cm and the length 12 cm. The laser-beam diameter in the cell was ~1.3 cm, and the radiation power 15 W. The beam could be moved parallel to the cell axis. The mixture was analyzed by means of the IR spectrum of the oscillations ν_3 $^{10}BCl_3$ (995 cm^{-1}) and ν_3 $^{11}BCl_3$ (956 cm^{-2}).

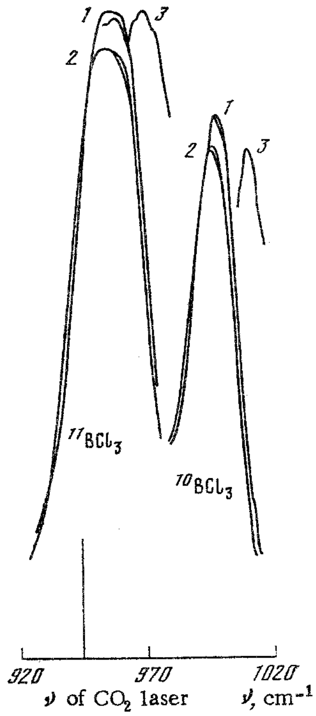

Fig. 5. IR spectrogram of BCl_3 (here BCl_3 + He = (5.4 + 18) torr). 1, 3) Absorption spectra of nonirradiated BCl_3; 2) absorption spectrum of BCl_3 acted upon by CO_2-laser radiation. The distance between the laser and globar beams is 3.6 cm, the irradiation power is 15 W.

An advantage of this method of investigation is that the gas system is completely closed. The absorption spectrum of the gas in a definite region of the cell, when the laser radiation acts on another region, was compared with the standard spectrum with the laser turned off. A shortcoming of the spectral analysis is the difficulty of investigating the spectrum in the hot zone. In this zone, the vibrational bands broaden on the low-frequency side, and hot bands appear. To get rid of the hot bands, we investigated the IR spectrum only in the cold band at a sufficient distance from the laser beam; we investigated BCl_3 to which only a cooling gas (He) was added, at low irradiation intensities. The limitation of the intensity has enabled us to analyze the LTD process at only a small temperature gradient, when the thermal-diffusion constant α is negative. In the analysis zone (cold zone), the $^{10}BCl_3$ + $^{11}BCl_3$ + He mixture was enriched with $^{10}BCl_3$ molecules, and at the same time the concentration of the BCl_3 decreased relative to He. The heavy components of the mixtures are drawn out into the region of the laser beam.

Figure 5 shows one of the spectrograms. Curves 1 correspond to the IR absorption spectrum of BCl_3 with the laser turned off, and curves 2 with the laser turned on (five curves were plotted after heating the mixture by the laser radiation for 5 min). Curves 3 are sections of the standard spectrum of BCl_3 (which is displaced for the sake of clarity), the pressure being chosen such that the amplitude of ν_3 $^{10}BCl_3$ coincides with the amplitude of the same band with the laser turned on (curve 2). The spectrum was repeatedly recorded with the laser turned on in order to verify that the spectrum remains unchanged during the recording time. The same figure shows clearly the decrease of the ν_3 $^{10}BCl_3$ and ν_3 $^{11}BCl_3$ bands when the laser is turned on, with the decrease of ν_3 $^{11}BCl_3$ the stronger.

The results of the spectral investigation are shown in Fig. 6. With increasing distance from the laser beam, the enrichment of the mixture with $^{10}BCl_3$ molecules increases. With increasing He concentration, the temperature gradient decreases, and this leads to a decrease of the separation. The low accuracy of the measurement of η and the narrow range of BCl_3 pressures did not make it possible to carry out quantative calculations of the thermal diffusion in this case. Nonetheless, the large separation coefficients in these experiments attest to the existence of intense LTD processes.

6. Experiments were performed on LTD of the mixture $^{10}BCl_3$ + $^{11}BCl_3$ + He, using a sectionalized cell. The cell consisted of three sections in tandem, each 30 cm long and 1.2 cm in diameter, interconnected by valves. A laser beam of ∿6 mm diameter was passed along the horizontally placed cell. The laser power was 10 W. Immediately after turning off the laser, the valves were closed. A comparative IR-spectral analysis of the composition of the mixture on the outer sections of the cell was made. Just as in the preceding experiments, in the

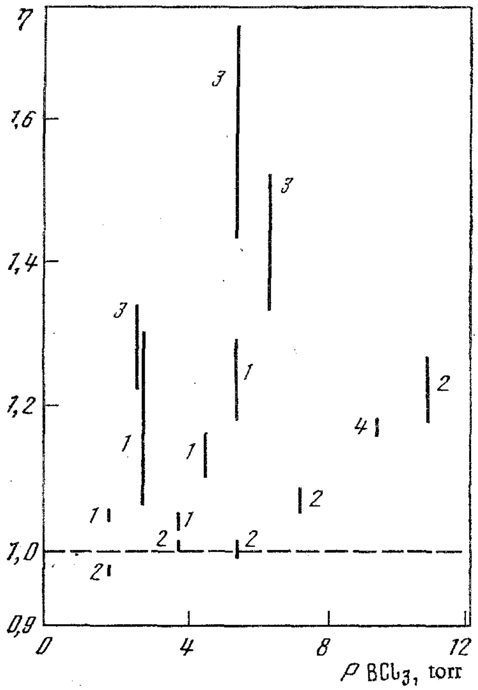

Fig. 6

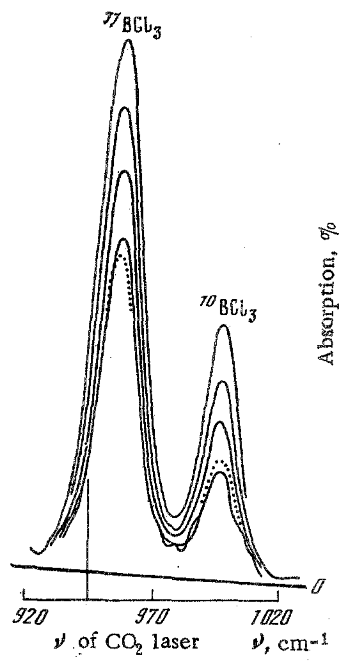

Fig. 7

Fig. 6. Dependence of the separation coefficient $\eta = \left(\frac{n^{10}BCl_3}{n^{11}BCl_3}\right)_{cold} \Big/ \left(\frac{n^{10}BCl_3}{n^{11}BCl_3}\right)_0$ for the mixture BCl_3 + He on the pressure of the BCl_3 at various helium pressures (P) and on the distance between the laser and the globar beams (l); irradiation power 15 W. 1) P_{He} = 18 torr, l = 1.6 cm; 2) P_{He} = 180 torr, l = 1.6 cm; 3) P_{He} = 18 torr, l = 3.6, cm; 4) P_{He} = 180 torr, l = 3.6 cm.

Fig. 7. IR spectrogram of BCl_3 (mixture BCl_3 + He = (7.5 + 600) torr). The dotted curve pertains to the absorption spectrum of BCl_3 from the cold zone, the remaining curves pertain to BCl_3 from the hot zone. Irradiation power 10 W.

cold zone (in the section farthest from the entrance of the laser beam) there was observed enrichment of the mixture with $^{10}BCl_3$ molecules, while in the hot zone (in the closest zone in the path of the beam) the enrichment was with $^{11}BCl_3$ molecules. The cold zone was richer in helium than the hot zone.

Figure 7 shows a spectrogram of BCl_3 drawn from the hot zone (the different curves corresponding to different pressures of the investigated gas in the pass-through cell of the spectrophotometer) and from the cold zone (the dotted curve).

The mixture was irradiated for 10-20 min. At BCl_3:He = 1:80-100 and at a BCl_3 pressure of 5-10 torr, the separation obtained was

$$\eta = \left(\frac{n^{11}BCl_3}{n^{10}BCl_3}\right)_{hot} \Big/ \left(\frac{n^{11}BCl_3}{n^{10}BCl_3}\right)_{cold} = 1.15\text{-}1.20.$$

After turning off the laser, during the time required to close the valves between the cold sections (∿0.5 min), the partial pressures of the gas in the sections could become partially equalized. Therefore, the measured values of the separation coefficients η must be regarded as underestimated.

7. Thus, the investigation of the diffusion processes that take place in gases under the influence of laser radiation demonstrate them to be different from the usual thermal-diffusion processes.

It seems possible to use laser radiation not only to separate isotopic and nonisotopic resonantly absorbing mixtures with selective and nonselective excitation of one component, but also to initiate thermal diffusion in nonabsorbing gases by strongly heating them and adding an absorbing gas to them.

The LTD separation coefficient is increased if accumulating convection columns are used. In our opinion, LTD stands out among all other methods of laser separation of isotopes and substances, being simplest and technologically more accessible, and also in that the equipment and accessories are similar to those used in traditional methods. A distinguishing feature of the LTD is also the large range of working pressures and irradiation intensities.

Interesting LTD effects can take place in resonantly absorbing mixtures under intense irradiation, which leads to a strong multilevel excitation and dissociation of the molecules. A change in the composition of the gas in the laser beam will affect the dynamics of the propagation of the beam in such a medium. The LTD should lead to gas streams along the laser beam, i.e., along the intensity gradient, and this can cause convection similar to that which occurs in thermal diffusion in a gravitational field. The LTD effects play apparently an important role in gas laser media, in saturable filters, and in other media subjected to intense resonant irradiation.

Particular interest attaches to dynamic LTD, which can appear in the case of post-laser action on a resonant medium, as well as in the collisional part of a gasdynamic stream or in the region of interaction of crossing beams.

Finally, laser excitation of molecules should change the collisional interaction between molecules situated in a field of external forces. One can therefore hope to attain laser stimulation of centrifuging, methods that make use of jet eddies, and others.

LITERATURE CITED

1. N. V. Karlov and A. M. Prokhorov, Usp. Fiz. Nauk, 118, 585-609 (1976).
2. K. S. Gochelashvili, N. V. Karlov, A. N. Orlov, et al., Pis'ma Zh. Eksp. Teor. Fiz., 21, 640-643 (1975).
3. K. S. Gochelashvili, N. V. Karlov, A. I. Ovchenkov, et al., Zh. Eksp. Teor. Fiz., 70, 531 (1976); N. V. Karlov, R. P. Petrov, Yu. N. Petrov, and A. M. Prokhorov, Pis'ma Zh. Eksp. Teor. Fiz., 24, 289-292 (1976); K. S. Gochelashvili, N. V. Karlov, N. A. Karpov, et al., Pis'ma Zh. Tekh. Fiz., 2, 721-727 (1976).
4. N. V. Karlov, N. A. Karpov, and Yu. N. Petrov, Kvantovaya Elektron. 2, 1563-1565 (1975).
5. H. Gueguen, F. Yzambart, A. Chakroun, et al., Chem. Phys. Lett., 35, No. 2, 198 (1975).
6. Thermodynamics of Gases [in Russian], Mashinostroenie, Moscow (1970).
7. K. E. Grew and T. L. Ibbs, Thermal Diffusion in Gases, Cambridge Univ. Press (1952).
8. F. S. Klein and J. Ross, J. Chem. Phys., 63, No. 10, 4556 (1975).